Audio Attenuator

reduce signal levels — to spec

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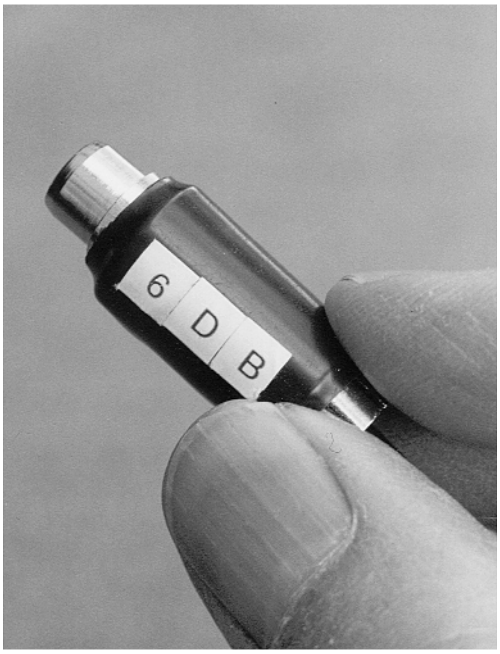
It happens very often that there is a marked change in the sound level when you change the audio source. However, you can quickly put an end to this with a simple attenuator network.



Fortunately, with modern audio equipment this problem is not as bad as it used to be. Quite a few years ago, the differences between the usual output levels and input sensitivities were, to put it mildly, striking. Browsing through some old amplifier specification sheets from the 1970's, we see 'standard' input sensitivities for the tuner and tape inputs of 155 mV, 180 mV, 200 mV, 220 mV, 250 mV and 300 mV. Nowadays, the situation is not as bad, but there are still differences.

Overdriving

Actually, there are two separate problems. In addition to the variation in the standard input and output levels (which fortunately is much less than it used to be), there is also a risk of overdriving the amplifier This is unfortunately still still a serious problem.

If we have a quick look at the specifications of modern audio equipment, we see that the input sensitivity of the line inputs (tuner, tape and CD) is 200 mV for most amplifiers. Remarkably enough, receivers deviate from this value; most of them adhere to a standard sensitivity of 150 mV. It's not clear why there is this difference, but it is relatively small and essentially not all that important.

Much more important is the fact that the 'old-fashioned' level of 200 mV is a total mismatch with the standard output levels of modern CD, DVD and MD players. Without exception, these devices provide a maximum voltage of 2 V at the output. This is a factor of ten higher than the sensitivity of the input to which the signal is connected!

Of course, it is true that the average level of a CD recording is 12 dB below the maximum, which means that the average output level is only 500 mV. Although this is still a factor of $2^1/_2$ too high, it appears to be a bit less disastrous. However, this is an illusion, since even if the CD is properly recorded at the prescribed level, the signal peaks will still reach 2 volts. If the amplifier in question is already fully driven at 200 mV, such peaks will cause strong clipping, which has many undesirable consequences.

Resistive divider

Fortunately, a signal source that delivers too much voltage, either in absolute terms or in comparison to other signal sources, can easily be brought back into line. A simple voltage divider, as shown in **Figure 1**, is all that you need. The degree of attenuation is determined by the ratio of resistors R1 and R2. In the example shown in **Figure 1**, the attenuation is 0.5, or a factor of 2. The attenuation can also be expressed in dBs; in this case it is –6 dB. The formula for calculating the attenuation in dBs is:

attenuation = 20 log[R2/(R1+R2)].

For purposes of illustration, and in order to save practically oriented readers the trouble of making the calculations, we have prepared a number of examples that are shown in **Table 1**. These are based on standard E12-series resistance values. You will probably not need the 2.5 dB and 3.3 dB versions very often, but in light of the previously mentioned level differences, you will likely reach for the –6 dB and –12 dB attenuators fairly often.

Matching

In addition to the ratio of R1 to R2, we also have to be concerned with the absolute values of these resistors. What are the guidelines?

On the input side of the attenuator,

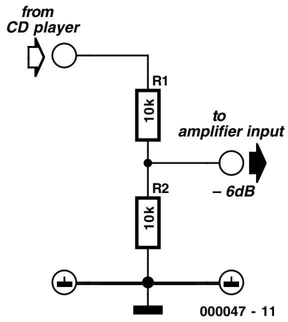


Figure 1. A simple resistive divider can be used to attenuate a signal to any desired degree.

we need to consider the output impedance of the signal source, while on the output side we have to consider the input impedance of the amplifier.

is to load the signal source as little as possible, since overloading can cause frequency-dependent attenuation. This degrades the linearity of the signal source, which is naturally not allowed in a hi-fi installation. In addition, too much attenuation will increase the noise level.

With regard to all this, is there a rule that we should or must obey? The answer is yes, and the rule is that the load impedance should be at least ten times as high as the output impedance of the signal source. This situation is illustrated in **Figure 2**. The output impedance of most signal sources is usually between one hundred and several hundred ohms. If we keep the sum of R1 and R2 between 10 kΩ and 20 kΩ, we will thus always be on the safe side, and we need not be worried about overloading the signal source. This has

serious. For example, if you make the precise calculations, you will find that the 9.9 dB attenuator actually yields an attenuation of 10.8 dB with a source impedance of 600 Ω and a load impedance of 47 kΩ This is a truly negligible difference.

Construction

In terms of construction, there are naturally various ways to achieve the same objective. The accompanying photographs show that you can very easily make an in-line attenuator using a Cinch plug and a Cinch cable socket. If you use 1/8-watt resistors, they will easily fit in the space between the plug and the socket. If you wish, you can then slide a piece of metal or plastic tubing over the assembly and finish it off with heat-shrink tubing. Mark the attenuation value on a sticker applied to the module, and you're done.

Note that the connection between such an 'attenuator plug' and the amplifier input should be either direct, or via a cable that is as short as possible. You may use a longer cable for the (low impedance) connection between the signal source and the attenuator.

If you frequently experiment with the various parts of your audio installation, you will probably find it handy to have a complete set of the attenuators listed in **Table 1**. For the active audio hobbyist, such a set is just about essential!

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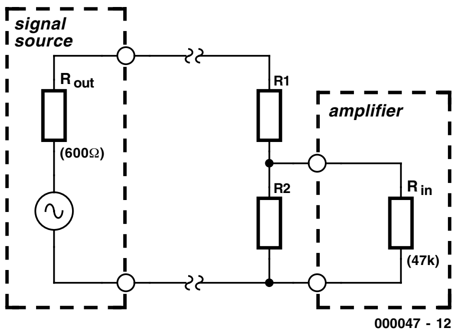

Figure 2. The source impedance must be taken into account when choosing the values of R1 and R2.

In high-frequency technology, the objective in this case is always to maximise the power transfer. This means that it is a good idea to ensure that the input impedance of the attenuator matches the output impedance of the signal source.
In audio technology, completely different rules apply. Here the objective

been taken into account in calculating the values listed in **Table 1**.

The input impedance of the amplifier is almost always 47 kΩ. This resistance stands in parallel with the resistance of R2, and that naturally affects the divider ratio of the network. In practice, however, the resulting deviations are not all that

Table 1

Attenuation	Attenuation in dB	R1	R2
0.75 ×	2.5	3.3 kΩ	10 kΩ
0.68 ×	3.3	4.7 kΩ	10 kΩ
0.50 ×	6.0	10 kΩ	10 kΩ
0.36 ×	8.9	10 kΩ	5.6 kΩ
0.32 ×	9.9	10 kΩ	4.7 kΩ
0.25 ×	12.1	10 kΩ	3.3 kΩ

Figure 3. A Cinch plug and cable jack can be used to make a handy in-line connector with a built-in attenuator.